Design of a Hand Operated Film Drive Mechanism

The R. A. Morgan Optical Engineering Company was founded by Mr. Robert Morgan in 1963. Previous to the founding of the company Mr. Morgan directed the design-engineering group at Itek Corporation, also an optical engineering company. He had also worked on mechanical computer equipment for the Burroughs Corporation and had developed aerial cameras for the Signal Corps and Air Force while working for the Hycon Company.

Mr. Morgan's new company originally occupied the downstairs rooms of an old apartment building in Palo Alto, California, near Stanford University. He was his only employee and had to do a lot of fast talking to get any contracts to do optical work. Since then the company has grown into a respectable research and development corporation with a new location in a modern business building on Park Boulevard in Palo Alto. The company has developed a large line of products in the short time that it has been in existence. These include rear projection viewers, cameras, telescopes, film drives, and similar optical equipment.

Prepared in the Design Division, Department of Mechanical Engineering, Stanford University, by John Sondeno, with support from the National Science Foundation. The Assistance of Mr. Robert A. Morgan is gratefully acknowledged.

The Roll Film Drive

In March of 1967 the Morgan Company was contacted by Mr. Gordon Anthony of the Keuffel and Esser Company (K & E) branch office in San Francisco. Mr. Anthony had received an order for two Itek 18 x 24 reader-printers (K & E # 52 2038, Exhibit I) from the Lockheed Aircraft Corporation in Sunnyvale, California. K & E serves as the distributor for the Itek Corporation reader-printer, as it does for many other items. Lockheed wanted the machine only if it could be modified to take 105mm roll film as well as 105mm cut sheets. Mr. Morgan said that he had done business in the past with the K & E people, so they knew that the Morgan Company did this sort of thing. Mr. Anthony asked Mr. Morgan to bid on the job, so Mr. Morgan went to San Francisco to have a look at the machine. He said, "I quoted some figure; I think it was around $2000 to do the job. I figured about a week of design time and a week and a half to manufacture. Actually it turned out to be a lot harder than I thought it was at the time, which is what happens in many modification cases."

A formal proposal (Exhibit 2) was sent to K & E by the end of March. Bob remarked that in cases where there is a good relation with a customer the proposal is often not more than a few pages long; whereas with customers such as the military one can write a small book on an item and still have little chance of getting the job.

By June the Morgan Company had received an order along with the two machines to be modified. Mr. Morgan said, "They sat around for a couple of months. We were just too busy on other projects, and you know how you always put off the smaller things. Finally, we figured we had better do something so we rented a designer from a job shop and let him go. I'm afraid he wasn't too well supervised. Fred (the chief engineer) and I were so busy. You know, designers are sometimes not too imaginative when it comes to alternative schemes. Ted (the designer) ot fixed on one design."

The Design Problem

The problem of the film drive could be divided into two parts. Mr. Morgan called them "thing A" and "thing B". (See Figure I below.) There was also a mechanism which allowed the film to lift off the projection stage while it was in motion. This prevented the emulsion side of the film from being scratched while the film was moving. (See Exhibit 5.) This mechanism is not discussed here. Thing A was the problem of designing some sort of transmission to turn a drive shaft for the film spools manually in a "manner that will be convenient to the operator and aesthetically attractive". Thing B was the problem of somehow connecting two non-intersecting drive shafts perpendicular to each other. The geometry of the existing machine dictated the basic set-up shown in the sketch.

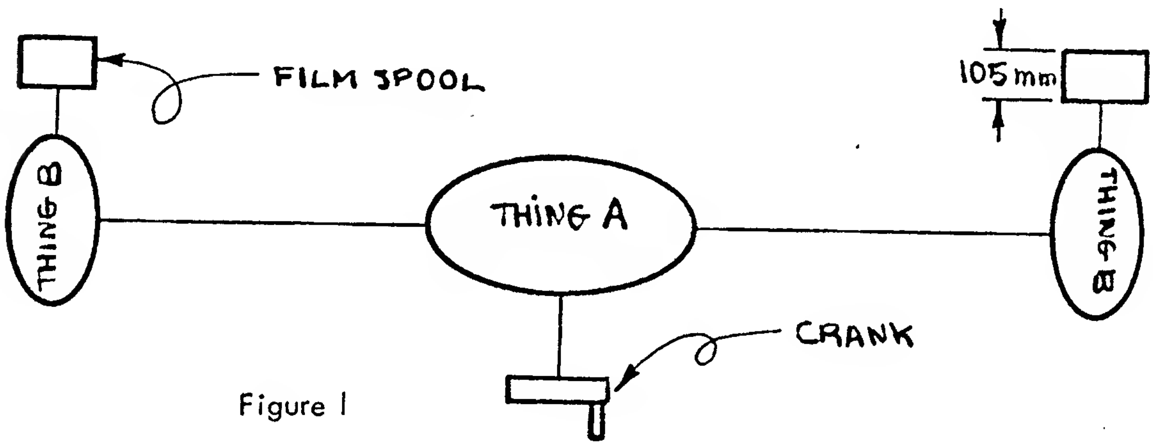


Figure I

The designer, Ted, concerned himself first with thing B. His first inclination was to use helical gears, but he found that there just was not room enough, so he selected a belt and pulley arrangement as follows:

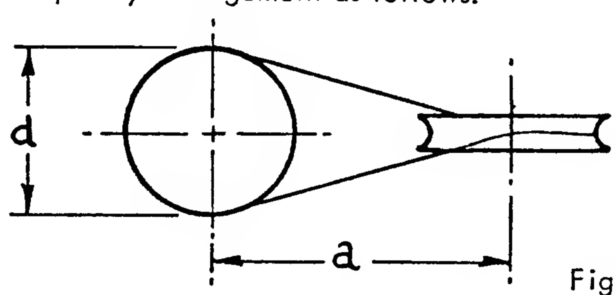


Figure 2

Mr. Morgan seemed to think this would work, on the face of it anyway, so he let Ted go ahead. But one day he was working in the assembly room on another project and ran across a similar problem where pulleys were being used. Bob asked the shop

assembler if he could think of any source of problems in the arrangement. The shop man indicated that if the distance between shafts (a) is small compared to the diameter (d) then the belt simply will not stay on. This raised Mr. Morgan's suspicions; he thought it would be a good idea to check with the P.I.C. Corporation who sold the pulleys and belts to see if the dimensions were all right. Mr. Morgan said, "They said everything was all right, but I was stupid to believe them. We were running short of time and were desperate for a workable scheme. Anyway I had thought of another way to do it if this thing didn't work." His other scheme is illustrated in the following sketch (Figure 3):

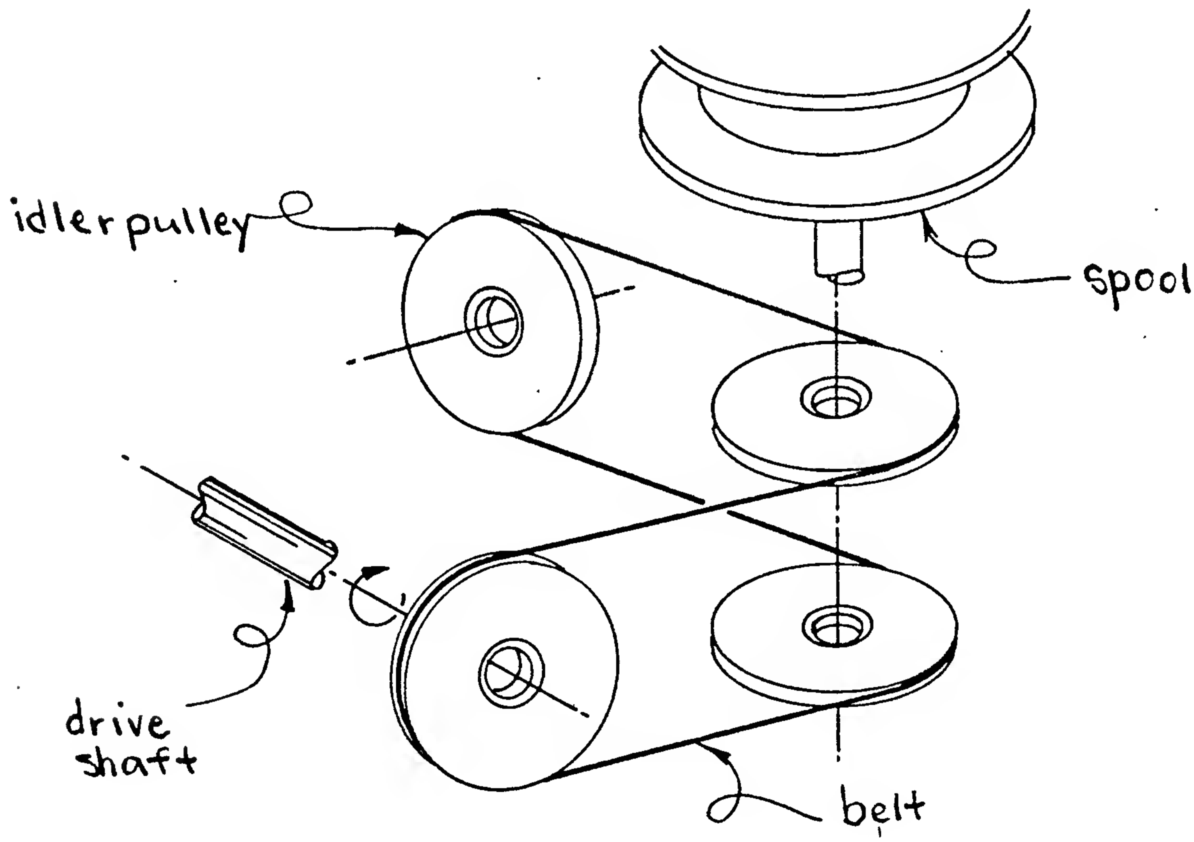


Figure 3

"Actually," said Mr. Morgan, "with this other scheme we only got a 90° wrap around, but I couldn't find any belts in the catalogue that were short enough to let us get the 180° that we could have used." The following (Figure 4) is a sketch made by Mr. Morgan at the time, illustrating the two ideas:

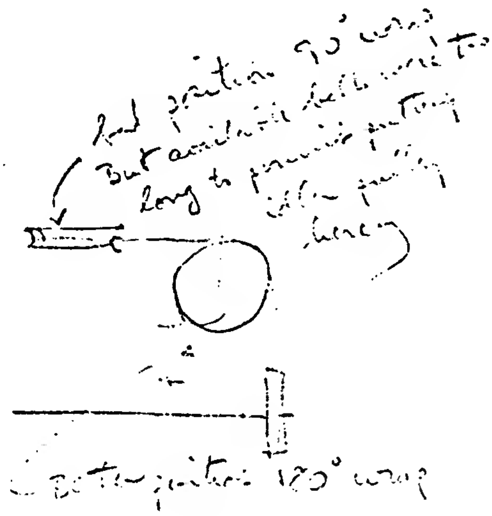


Figure 4

Mr. Morgan said that they couldn't afford to have the belts slipping, so a caterpillar type belt was selected. The "pulleys" would be like spur gears that had a groove cut in them for the body of the caterpillar whose legs then fit between the gear teeth. (See Exhibit 3.) As one might have guessed by this time, the first scheme did not work and they ended up using the second scheme at the last minute.

The hand crank mechanism gave Mr. Morgan much less trouble than the pulleys and belts, although it was much more complex. He said, "I think I must have found some other ways; I never stop with a single solution. But I came upon this fairly quickly and liked it, so I went ahead and told Ted to work out the details." Actually, Mr. Morgan did mention a few other alternatives. One was the idea of a swing clutch (illustrated in Figure 5 below), but he said that I.B.M. used a mechanism very similar to this and he didn't want to run into patent troubles.

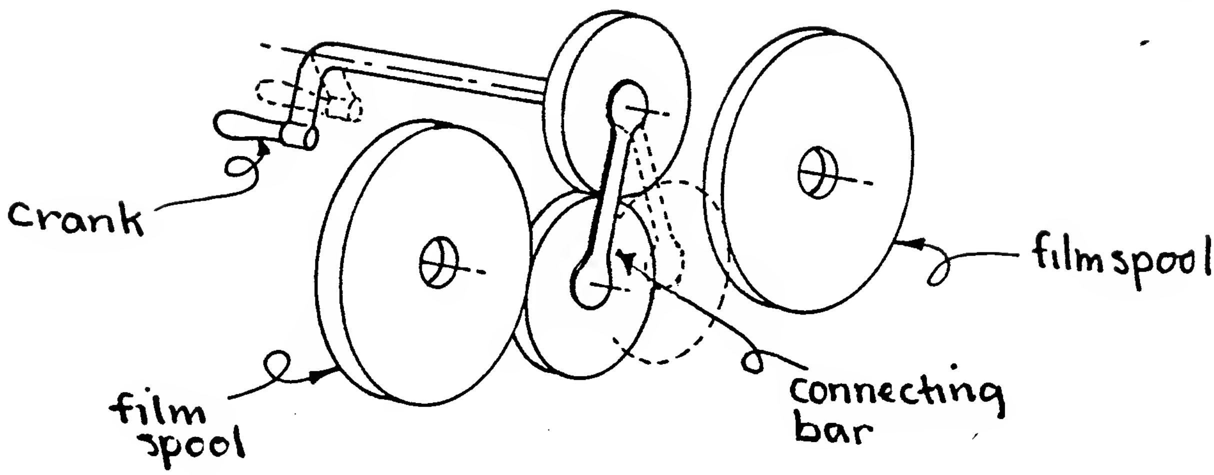


Figure 5

Swing Clutch Concept

As the crank is turned, the driving wheel will engage one film spool while disengaging the other. When the crank is turned in the opposite direction, the driver spool is disengaged and the opposite spool is engaged. Thus, alternate driving of spools is provided for winding and unwinding of the film.

Mr. Morgan also considered simply having two hand cranks, one to drive one spool and the other to drive the other spool. He said, "I can't think now why we felt it to be so bad to have two cranks instead of one, but I suppose nobody is good at cranking with his left hand." Mr. Morgan's final idea is shown in Exhibit 4.

The idea was that when the crank was turned one way or the other, not only was a rotary motion transferred to the drive shaft though the two perpendicular helical gears shown in the exhibit, but also a thrust to the right or left was developed depending on whether the crank was being turned to the left or right respectively. This thrust was forceful enough to close one of two clutches on either side of the two perpendicular helical gears, and to open the opposite clutch. Thus, when the hand crank was being turned one way, one spool was being driven and the other was free. When the hand crank was turned the opposite way, the free spool became the driven spool and the driven spool became the free spool.

The problem of braking so that there would not be any overrun by the free spool when the driving spool was stopped suddenly, turned out to be less of a problem than Mr. Morgan had anticipated. There was enough friction in the system to keep this from happening except with the most violent operation of the handcrank. And even then, upon a sudden stop there was a tendency for the operator to overcorrect; thus, an opposite thrust was induced in the drive shaft by the helical gears, engaging the opposite clutch and braking the free spool.

The adjustment of the spacing between the clutches was done by shimming the adjoining shafts. (See Exhibit 4.) The shims (thin washers) were placed between bearing blocks A and shafts B so that there was about .002 inches between the clutch faces of a disengaged clutch (either one). This was done by putting a piece of paper between the clutch faces of either clutch and then shimming until the clutch closed on the paper. (The paper upon which this is printed is about .002 inches thick.) The spacing was not critical. The helical gears at right angles could slip past each other easily 1/32 inch (.0312 inch) without affecting the torque transferred at all. In fact, the gears were about 1/4 inch wide and could slip past each other 1/8 inch and still drive the main shaft as long as the gears remained in contact. Mr. Morgan remarked that if he were to do it again he would not use shims but would have used set screws on one of the clutches instead pinning them to the shaft as they are now. For example, clutch face C (See Exhibit 4 again.) could be adjusted relative to clutch face D using a piece of paper between the faces. Then the set screws could be tightened and that would be that. It was desirable to have the clutches as close together as possible without engaging so that the operator would have positive control with minimum backlash in the system.

Mr. Morgan also incorporated a bit of gearing into the drive mechanism to compensate for about a 5 to 1 speed difference in the film crossing the film stage between the nearly empty driving spool condition and the full driving spool condition for a constant crank speed. To compensate for the "inconvenience to the operator" in keeping the film speed constant a two speed transmission was added. (See Exhibit 5.)

Exhibit 6 illustrates an assembly drawing of the clutch-gear mechanism. In September of 1967 the two reader-printers were delivered to Lockheed.

Modifications

In April of 1968 the Morgan Company was again contacted by Mr. Anthony who stated that Lockheed was having trouble with the film drives and that he wished that the Morgan Company would fix it. Bob agreed to repair the drives. He expected to continue selling the film drives to K & E and felt that it would be worthwhile to improve the design if necessary in order to have a dependable product.

The main problem was that the caterpillar belts had stretched and were slipping over the teeth in the "pulleys". This was corrected by incorporating a bead chain drive (Exhibit 7) in place of the caterpillar belt concept. The bead chains also stretch, but, as Mr. Morgan relates, "hopefully, not as much."

Another problem came about because the cork clutch faces had been put on with a pressure-sensitive cement backing and had simply come off. The design was changed so that the cork was not glued in place at all, but was held freely between the surface plates suspended on a slight extention of the main shaft into the clutch proper. (See Exhibit 8.)

A problem with the helical gears in one of the machines was somewhat confusing. Lockheed had complained of difficulty in turning the crank. The gears on one of the two machines showed considerable wear. Mr. Morgan said, "That second machine never did feel very good. The first one was okay. I think it was just a gear defect. Anyway, all we did was replace the gears."

Conclusion

Mr. Morgan stated, "I'll bet we lost a thousand on this thing. I sure wish we had done things a bit simpler. I didn't get a nickels credit for having the refinement

of a single hand crank for two spools. But the concept was fairly original. I am in the process of patenting the clutch drive idea. Also, K & E seems to think there are good prospects for selling more reader-printers with the roll film modification. I think we will more than make up for the money we lost."

ITEK Reader-Printer

MICRO-MASTER®

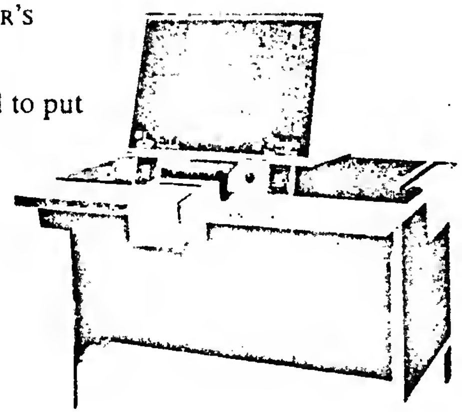
105mm AUTOMATIC VIEWER-PRINTER

Catalog No. 52 2038

adds a new dimension to your 105mm miniaturization system

The concept of 105mm as a total reproduction system has gained universal acceptance in the engineering documentation field. Like other microfilm negatives, its miniaturized size (4" x 6") makes the 105mm negative an ideal medium for document storage, quick retrieval and reference. But, as many reproduction departments know, the 105mm film negative does much, much more. It is an active reproduction tool to aid design, drafting and production. To realize the full potential of MICRO-MASTER® 105 mm, K&E has pioneered the design of components which extend the versatility and flexibility of this remarkable system.

Such a "systems-stretching" tool is MICRO-MASTER's new 105mm Automatic Viewer-Printer. With this compact, fully-automatic unit, the user is equipped to put his file of 105mm negatives to work to perform a wide variety of time and money-saving functions. With this revolutionary Viewer-Printer, anyone with a 105mm negative is capable of performing marvels of reference, reproduction and revision — adding a totally new dimension to the 105mm miniaturization system.



here's what you get:

IDEAL SATELLITE UNIT: Because of its compact size (occupies only 13 square feet), the Viewer-Printer will fit in virtually any location — drafting room or field office as well as reproduction department. Best of all, since prints are delivered fully processed, no darkroom is required.

SHARP VIEWING IMAGE: Throw the switch and you've got your 4X enlarged, pinpoint-sharp image on the 18" x 24" viewing screen. Do your viewing standing or seated in regular room light. The non-glare screen gives you a clear, easy-to-view image even over extended viewing periods.

FAST PRINT-OUT: No waiting for prints with this handy unit. Load your 105mm negative, push a button and — 20 seconds later — you receive a fully processed 18" x 24" print. This all-in-one "reproduction center" is simplicity itself to operate — no special operator training is required.

VERSATILE PRINT-OUT: You get line prints with photographic quality and fine-detail definition. And, using exactly the same sensitized materials you can obtain continuous tone and half tone prints. Print-out from line and continuous tone negatives can be combined on the same sheet, too.

FULL-RANGE COPYING CAPACITY: Whether it's one copy or several hundred, the Viewer-Printer puts that quantity within your reach at an unrivaled low cost. Get the single expendable print for pennies in seconds. Tie the unit in with other standard reproduction systems for multiple copies . . . Viewer-Printer delivers a translucent vellum print for use as a diazo master or paper offset master for larger print runs.

Exhibit 1

Morgan Proposal

March 29, 1967
Proposal 710

Keuffel & Esser Co.
2675 Folsom Street
San Francisco, California 94110

Attention: Mr. Howard F. Moritz

Gentlemen:

R. A. Morgan Co., Inc. is pleased to quote on the Modification of two Itek Reader Printers as follows:

1. Add a manually operated roll-film drive so 105mm film in spools up to 400 feet capacity may be accommodated.

2. Add a platen opening mechanism so the film will not be scratched when being pulled by the film drive.

3. Integrate these changes into the Itek machine in a manner that will be convenient to the operator and aesthetically attractive.

Cost of first unit: $1,972.00

Cost of second unit: $ 543.00

These prices are firm for 60 days.

Delivery can be made sixty days after receipt of the Itek Reader Printers.

Sincerely yours,

R. A. MORGAN CO., INC.

Robert A. Morgan
President

RAM:bjb

Exhibit 2

Morgan Proposal

April 13, 1967

KEUFFEL & ESSER CO.
2675 Folsom Street
San Francisco, California

Attention: Mr. Gordon D. Anthony

REF: Our Proposal No. 710 dated March 29, 1967

Gentlemen:

The following is suggested for wording of the specification requested by Lockheed for the modification of your 18x24 Reader/Printer.

18 x 24 Micromaster Reader/Printer modified as follows:

1. Roll film or cut sheets may be accommodated.
2. Spools up to 350' capacity can be accepted.
3. Spools will be driven by hand cranks.
4. The pressure plate will be automatically opened when film is advanced so the emulsion will not be scratched.
5. The modifications will be integrated into the basic Reader/Printer in a manner that will be convenient to the operator and aesthetically attractive.
6. The line cord will be fitted with a Hubbell Cap #9782.

Please consider this letter a supplement to our proposal 710.

Sincerely yours,

R. A. MORGAN CO., INC.

Robert A. Morgan
President

RAM:bjb

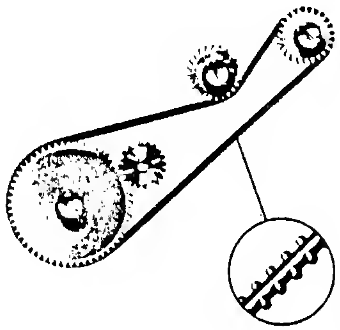
Exhibit 2

Drive Belt and Geared Pulley

New UNIQUE Patented

"NO-SLIP"

Positive Drive Belts and Geared Pulleys

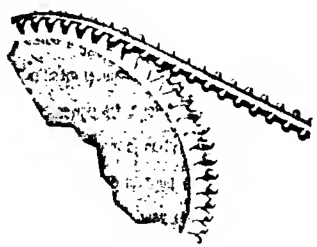


Ideally Suited for:

- BUSINESS MACHINES
- DATA RECORDING
- SERVO MECHANISMS
- MECHANICAL MOTIONS
- COMPUTERS
- VENDING MACHINES
- RECORDERS
- CHART DRIVES

Design Advantages:

- NO-SLIP • LOW TORQUE
- NO EXACT CENTER DISTANCES REQUIRED
- NO PRE-TENSION
- HIGH REDUCTIONS
- TOP OR BOTTOM BELT DRIVE
- LINEAR MOTION
- SILENT DRIVES
- SYNCHRONIZED MOTION
- NON-PARALLEL SHAFT DRIVES
- CONVENTIONAL GEARING DRIVE
- NON-METALLIC CONNECTION
- MINIMUM BACKLASH



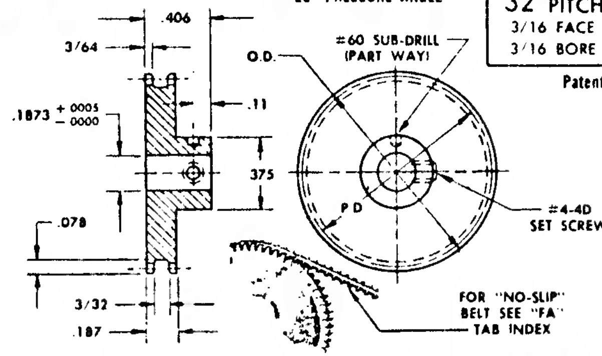
433

"NO-SLIP" GEARED PULLEY

20° PRESSURE ANGLE

32 PITCH
3/16 FACE
3/16 BORE

Patented



FC

PIC Precision 1 Tolerances
Total Composite Error .001
Tooth to Tooth Composite Error .0004

ORDER BY CATALOG NUMBER

Geared Pulley Data			Stainless Steel #303 Clear Passivated (After Cutting)		Aluminum 24ST Chromic Acid Anodized (Before Cutting)	
No. Teeth	+.000 −.001 P. D.	+.000 −.002 O. D.	Cat. No.	List Price	Cat. No.	List Price
15	4687	.5312	FC3-15	5.35	FC4-15	4.65
16	5000	5625	FC3-16	5.40	FC4-16	4.70
18	5625	6250	FC3 18	5.50	FC4-18	4.80
20	6250	6875	FC3-20	5.60	FC4-20	4.90
22	6875	7500	FC3 22	5.70	FC4 22	5.00
24	7500	8125	FC3 24	5.80	FC4 24	5.10
26	8125	8750	FC3-26	6.20	FC4 26	5.50
28	8750	9375	FC3 28	6.40	FC4 28	5.70
30	9375	1.0000	FC3 30	6.60	FC4 30	6.10
32	1.0000	1.0625	FC3-32	6.80	FC4-32	6.30
36	1.1250	1.1875	FC3 36	7.00	FC4 36	6.50
40	1.2500	1.3125	FC3 40	7.50	FC4-40	7.00
48	1.5000	1.5625	FC3-48	8.00	FC4 48	7.50
56	1.7500	1.8125	FC3 56	8.50	FC4 56	8.00
64	2.0000	2.0625	FC3 64	9.00	FC4 64	8.50
72	2.2500	2.3125	FC3 72	9.50	FC4 72	9.00
80	2.5000	2.5625	FC3 80	10.00	FC4 80	9.50
88	2.7500	2.8125	FC3 88	10.50	FC4 88	10.00
96	3.0000	3.0625	FC3 96	11.00	FC4 96	10.50
112	3.5000	3.5625	FC3 112	11.50	FC4 112	11.00
128	4.0000	4.0625	FC3 128	12.00	FC4-128	11.50

Other number of teeth available on request

440

Exhibit 3

Simplified Drawing of Film Drive

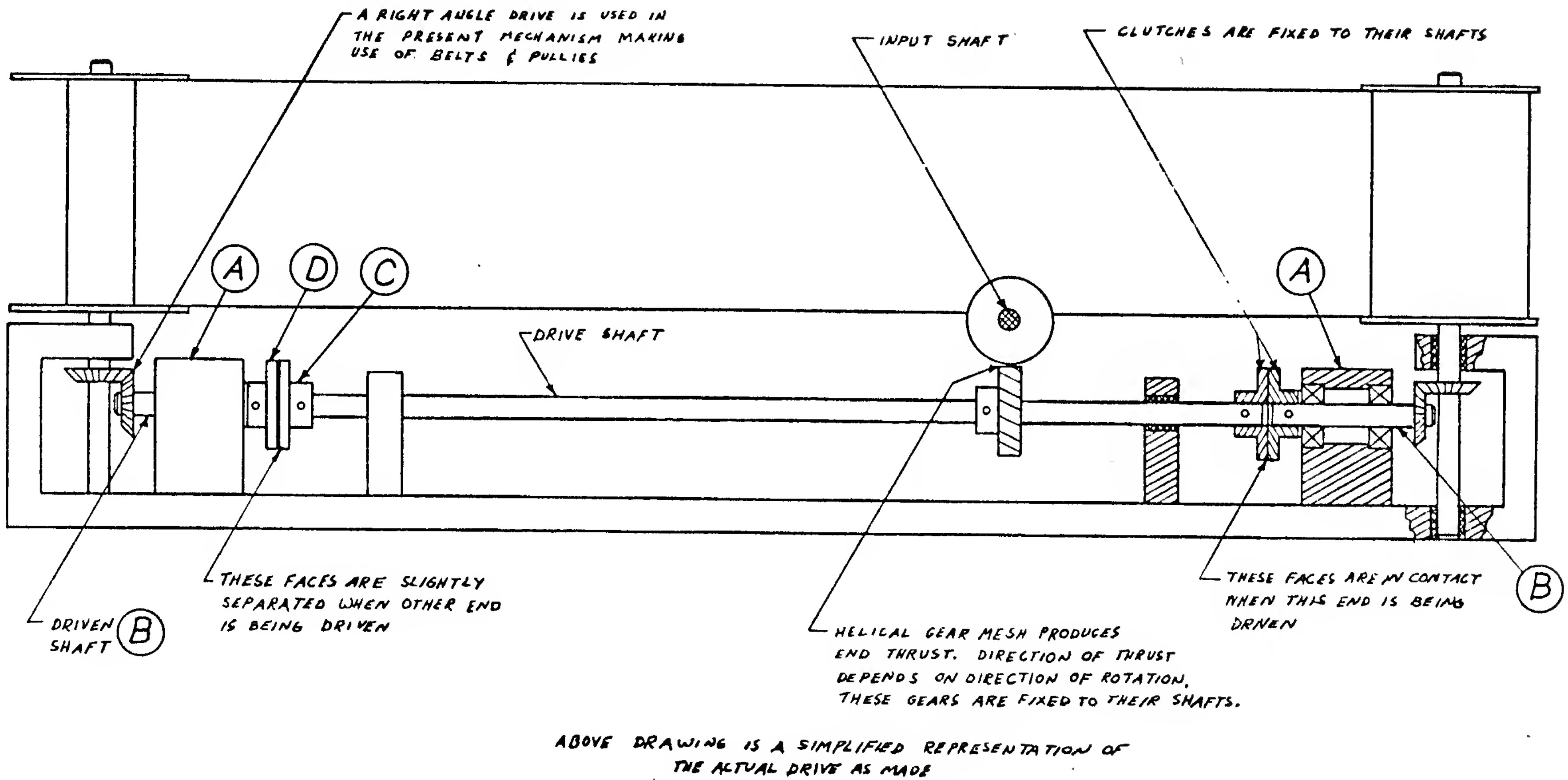
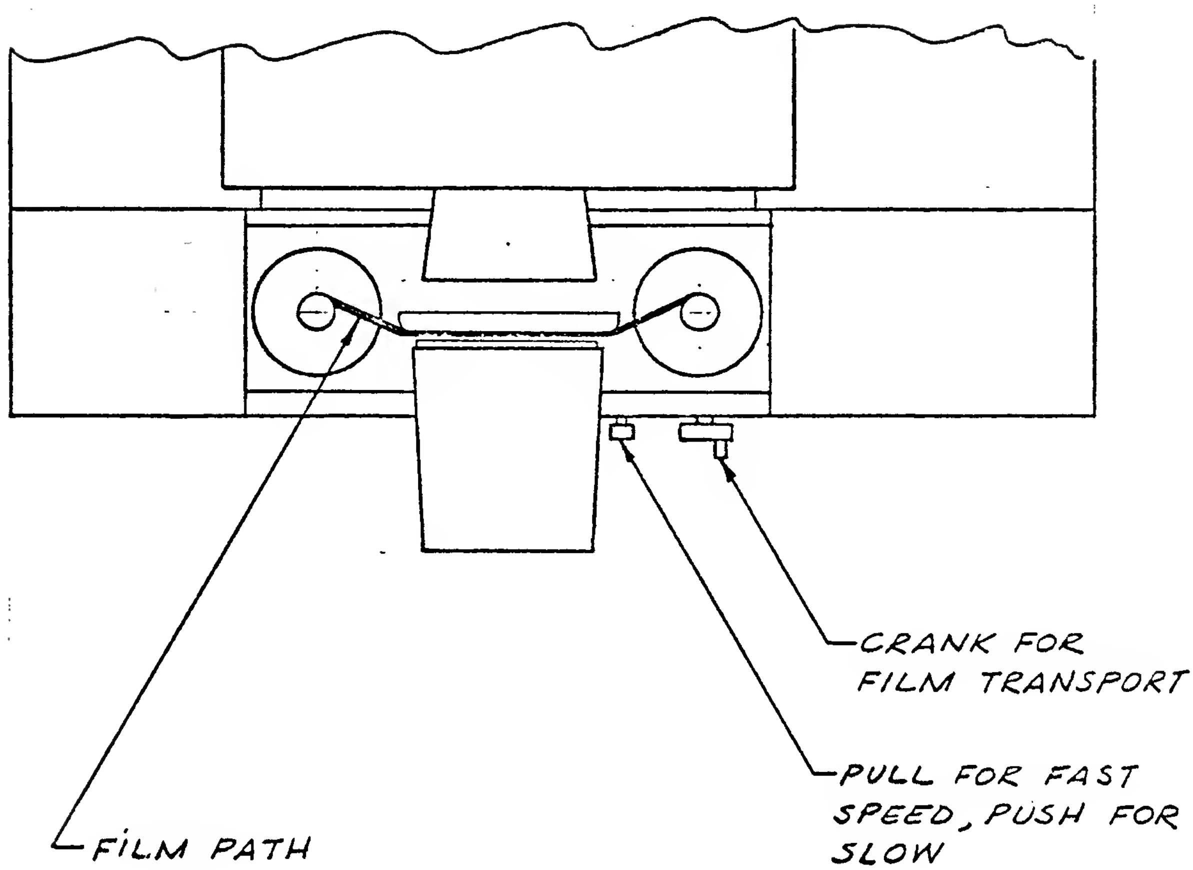


Exhibit 4

Roll Film Drive for K & E Reader/Printer



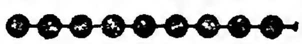
NOTE:

1. WHEN SHIFTING FROM FAST SPEED TO SLOW, OR SLOW TO FAST, JIGGLE CRANK TO FACILITATE ENGAGEMENT OF GEARS.
2. RAPID TRANSPORT OF FILM AUTOMATICALLY OPENS PLATEN TO PREVENT SCRATCHING FILM. FOR VERY SLOW TRANSPORT, OPERATOR MAY SLIGHTLY OPEN PLATEN BY HAND.
3. AFTER PLACING SPOOL ON SPINDLE, HOLD FLANGE OF SPOOL AND ROTATE CRANK BACK AND FORTH TILL DRIVE PIN ENGAGES HOLE IN FLANGE.

ROLL FILM DRIVE FOR
K & E READER/PRINTER

Exhibit 5

BEAD CHAIN AND BEAD BELT

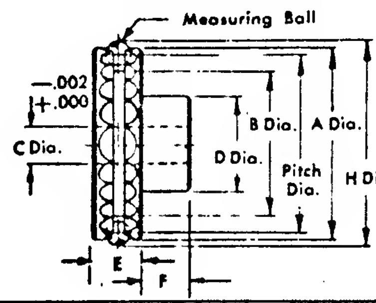
METALLIC BEAD CHAIN						
Code	Materials	Size	Bead Dia.	Pitch	No. of Beads	Used On
3-B 3-NB 3-SS	Brass Nickel Plated Brass Stainless Steel		3/32	.118 / .116	102/103 Beads/ft.	Brass Machined Sprockets
6-B 6-NB 6-SS	Brass Nickel Plated Brass Stainless Steel		1/8	.168 / .165	71½/72½ Beads/ft.	Brass Machined Sprockets N-6-24 Molded Nylon Sprockets and D-6-16 & D-6-32 Die Cast Sprockets
6X-B 6X-NB 6X-SS	Brass Nickel Plated Brass Stainless Steel		1/8	.176 / .172	69 Beads/ft.	N-6-16; N-6-18 and N-6-32 Molded Nylon Sprockets
10-B 10-NB 10-SS	Brass Nickel Plated Brass Stainless Steel		3/16	.240 / .235	50/51 Beads ft.	Brass Machined Sprockets
13-B 13-NB 13-SS	Brass Nickel Plated Brass Stainless Steel		1/4	.329 / .320	37 Beads ft.	Brass Machined Sprockets

BRASS MACHINED BEAD CHAIN SPROCKETS

A=Sprocket Outside Diameter
B=Groove Diameter
C=Bore Diameter
D=Hub Diameter
E=Sprocket Width
F=Hub Width
H=Diameter over Measuring Balls

Pitch Diameter=Dia. over Measuring Balls (H)
—Minus—One Measuring Ball Dia.

All Tolerances Unless Otherwise Noted ±.005



SPROCKETS FOR #3 QUALIFIED METALLIC BEAD CHAIN (.094 Measuring Ball Diameter)

Code	Sockets	A	B	C	D	E	F	H
3-12	12	.442	.255	.125	5/16	.187	3/16	.503
3-16	16	.575	.388	.125	5/16	.187	3/16	.652
3-20	20	.750	.563	.187	3/8	.187	1/4	.812
3-24	24	.895	.708	.187	7/16	.187	1/4	.971
3-30	30	1.130	.943	.187	1/2	.187	5/16	1.205
3-32	32	1.200	1.013	.187	1/3	.187	5/16	1.269
3-36	36	1.360	1.173	.187	1/2	.187	5/16	1.429
3-40	40	1.498	1.311	.250	1/2	.187	5/16	1.575
3-48	48	1.805	1.618	.250	5/8	.187	5/16	1.878
*3-60	60	2.240	2.053	.250	5/8	.187	5/16	2.304
*3-72	72	2.708	2.521	.250	5/8	.187	3/8	2.770

SPROCKETS FOR #6 QUALIFIED METALLIC BEAD CHAIN (.125 Measuring Ball Diameter)

Code	Sockets	A	B	C	D	E	F	H
6-12	12	.595	.375	.187	3/8	.250	1/4	.690
6-15	15	.760	.540	.187	1/2	.250	1/4	.862
6-16	16	.830	.610	.187	1/2	.250	1/4	.923
6-20	20	1.050	.830	.187	1/2	.250	1/4	1.150
6-24	24	1.270	1.050	.250	5/8	.250	5/16	1.374
6-30	30	1.602	1.382	.250	5/8	.250	5/16	1.685
6-32	32	1.692	1.472	.250	5/8	.250	5/16	1.791
6-36	36	1.920	1.700	.250	5/8	.250	5/16	2.013
*6-40	40	2.135	1.915	.312	3/4	.250	3/8	2.217
*6-48	48	2.536	2.316	.312	3/4	.250	3/8	2.639
*6-60	60	3.190	2.970	.312	3/4	.250	3/8	3.274
*6-72	72	3.800	3.580	.312	3/4	.250	3/8	3.895

SPROCKETS FOR #10 QUALIFIED METALLIC BEAD CHAIN (.187 Measuring Ball Diameter)

Code	Sockets	A	B	C	D	E	F	H
10-12	12	.850	.560	.250	5/8	.281	5/16	1.025
10-16	16	1.152	.862	.250	5/8	.281	5/16	1.344
10-20	20	1.465	1.175	.250	5/8	.281	5/16	1.662
10-24	24	1.775	1.485	.250	3/4	.281	3/8	1.980
*10-30	30	2.260	1.970	.250	3/4	.281	3/8	2.425
*10-32	32	2.392	2.102	.312	3/4	.281	3/8	2.588
*10-36	36	2.725	2.435	.312	3/4	.281	3/8	2.890
*10-40	40	2 990	2.700	.312	1"	.281	1/3	3.190
*10-48	48	3.630	3.340	.312	1"	.281	1/2	3.790

SPROCKETS FOR #13 QUALIFIED METALLIC BEAD CHAIN (.250 Measuring Ball Diameter)

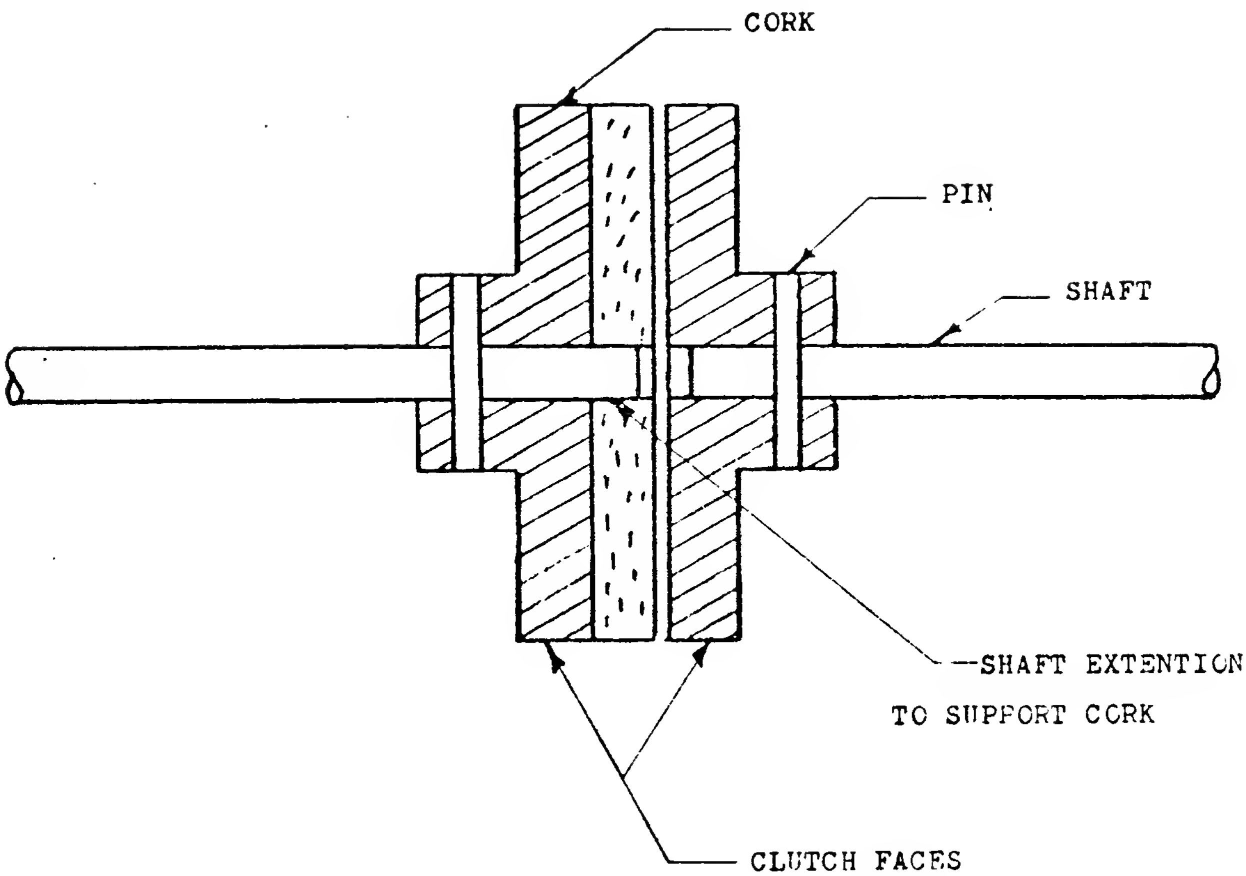
Code	Sockets	A	B	C	D	E	F	H
13-12	12	1.090	.670	.250	5/8	.375	5/16	1.333
13-16	16	1.525	1.105	.250	5/8	.375	3/8	1.790
13-20	20	1.960	1.540	.312	3/4	.375	1/2	2.212
*13-24	24	2.435	2.015	.312	3/4	.375	1/2	2.645
*13-30	30	3.065	2.645	.375	3/4	.375	1/2	3.292
*13-32	32	3.270	2.850	.375	3/4	.375	1/2	3.505

*Machined from cast blanks with lightened webs.
Hub Diameter (D) is as cast (wide tolerance).

Exhibit 7

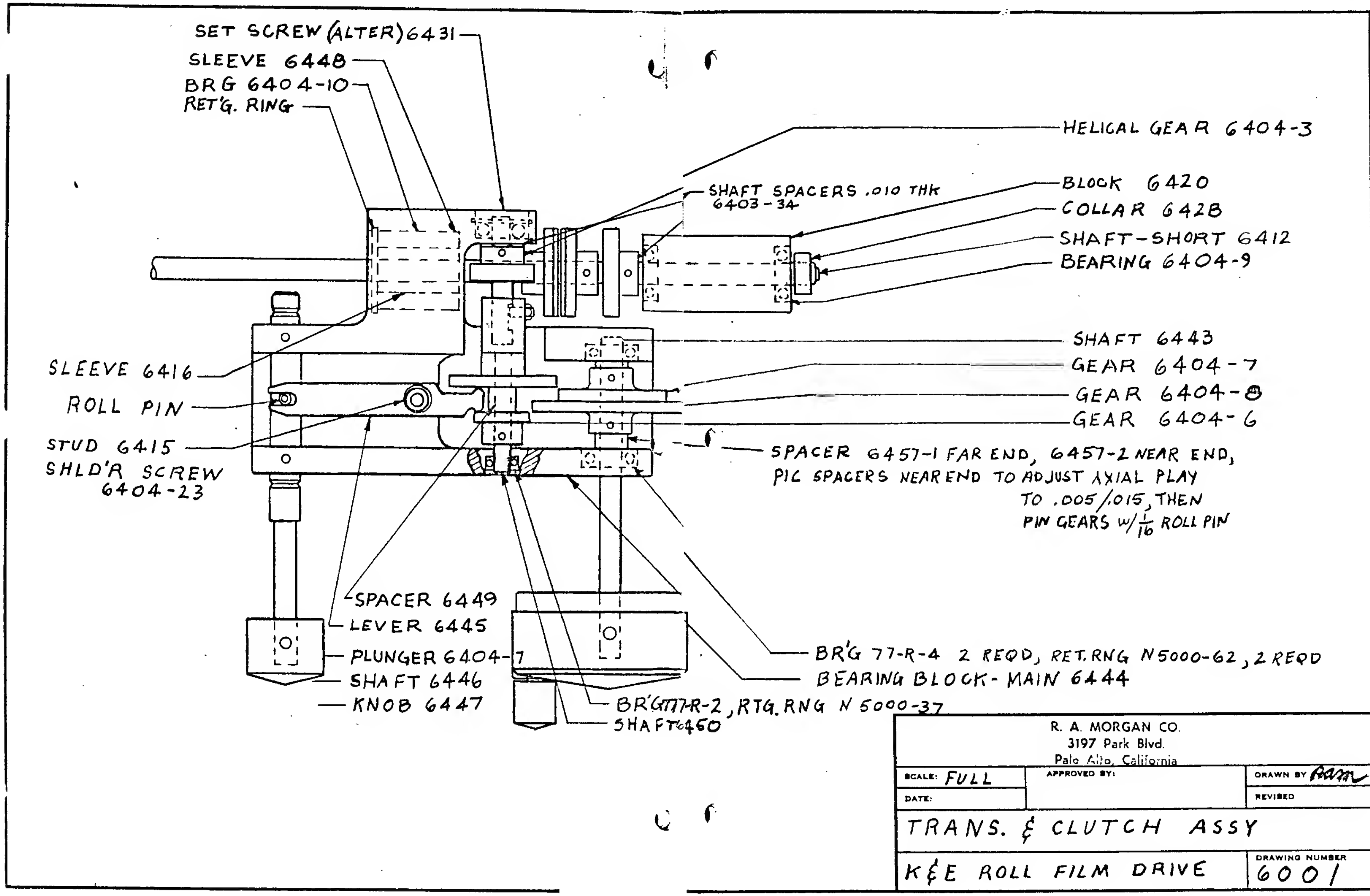
Manufactured under
U.S. Patents 2,791,911—2,825,231
Other Patents Pending

Modified Clutch Design



CONSTRUCTION OF MODIFIED CLUTCH DESIGN

Exhibit 8


SET SCREW (ALTER) 6431
SLEEVE 6448
BRG 6404-10
RET'G. RING
HELICAL GEAR 6404-3
SHAFT SPACERS .010 THK
6403-34
BLOCK 6420
COLLAR 6428
SHAFT-SHORT 6412
BEARING 6404-9
SHAFT 6443
GEAR 6404-7
GEAR 6404-8
GEAR 6404-6
SLEEVE 6416
ROLL PIN
STUD 6415
SHLD'R SCREW
6404-23
SPACER 6457-1 FAR END, 6457-2 NEAR END,
PIC SPACERS NEAR END TO ADJUST AXIAL PLAY
TO .005/.015, THEN
PIN GEARS W/ 1/16 ROLL PIN
SPACER 6449
LEVER 6445
PLUNGER 6404-7
SHAFT 6446
KNOB 6447
BR'G 77-R-4 2 REQD, RET. RNG N5000-62, 2 REQD
BEARING BLOCK-MAIN 6444
BR'G 77-R-2, RTG. RNG N 5000-37
SHAFT 6450
R. A. MORGAN CO.
3197 Park Blvd.
Palo Alto, California
SCALE: FULL
APPROVED BY:
DRAWN BY RAM
DATE:
REVISED
TRANS. & CLUTCH ASSY
K&E ROLL FILM DRIVE
DRAWING NUMBER
6001